PROTON-INDUCED POSITIVE PION PRODUCTION: THE STRIPPING MODEL

M. Tsangarides, J.G. Wills, and R.D. Bent
Indiana University Cyclotron Facility, Bloomington, Indiana 47405

The extent to which the extensive body of new data on the A(p,π^+)A+1 reaction near threshold ($T_p \lesssim 200$ MeV) can be explained by the DWBA Stripping Model has been investigated.[1-3] Unlike previous work, the theoretical calculations of the polarization asymmetries include the effects of both proton and pion distortions. To avoid unphysical off-shell divergences, a modified Laplacian pion-nucleus optical potential, which includes a multiplicative off-shell damping form factor, was used. Corrections for Pauli-blocking, true pion absorption, angle transformation and isoscalar contributions were also included. The DWBA code used standard proton and Coulomb distortions, the usual non-relativistic form of the pion-nucleon interaction in either its static or Galilean-invariant limit, and shell-model wavefunctions for the captured nucleon in a Woods-Saxon potential.

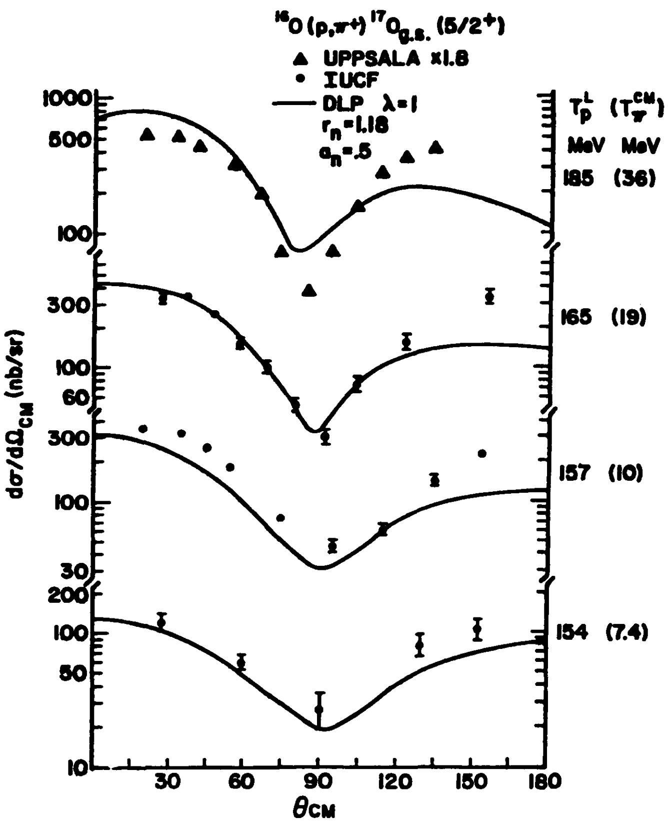

Figure 1. Data and DWBA calculations of the $^{16}O(p,\pi^+)^{17}O_{g.s.}$ differential cross sections at the proton incident energies of 185, 165, 157, and 154 MeV.

The DWBA calculations reproduce many of the main features of the energy- and A-dependence of the differential cross sections--for example, the shift in position of the first minimum in the ^{16}O(p,π^+)^{17}O$_{g.s.}$ and ^{40}Ca(p,π^+)^{41}Ca$_{g.s.}$ angular distributions (Figs. 1 and 2). While the sign of the analyzing power is given correctly for the ^{10}B(p,π^+)^{11}B$_{g.s.}$ and ^{12}C(p,π^+)^{13}C$_{g.s.}$ reactions (Fig. 3), the calculations are extremely sensitive to the form of the pion production operator {static (λ=0) or Galilean invariant (λ=1)} and to both proton and pion distortions. For the ^{40}Ca(p,π^+)^{41}Ca$_{g.s.}$ reaction, λ=1 gives a reasonably good fit to the differential cross section data but the wrong sign for the analyzing power, whereas λ=0 gives the correct sign for the analyzing power but fails to reproduce its angular variation and the differential cross section data.

Differential cross section and polarization asymmetry data together provide a stringent test of any reaction model. The failure of the DWBA calculations to fit simultaneously both types of data may be due to uncertainties regarding the form of the pion production

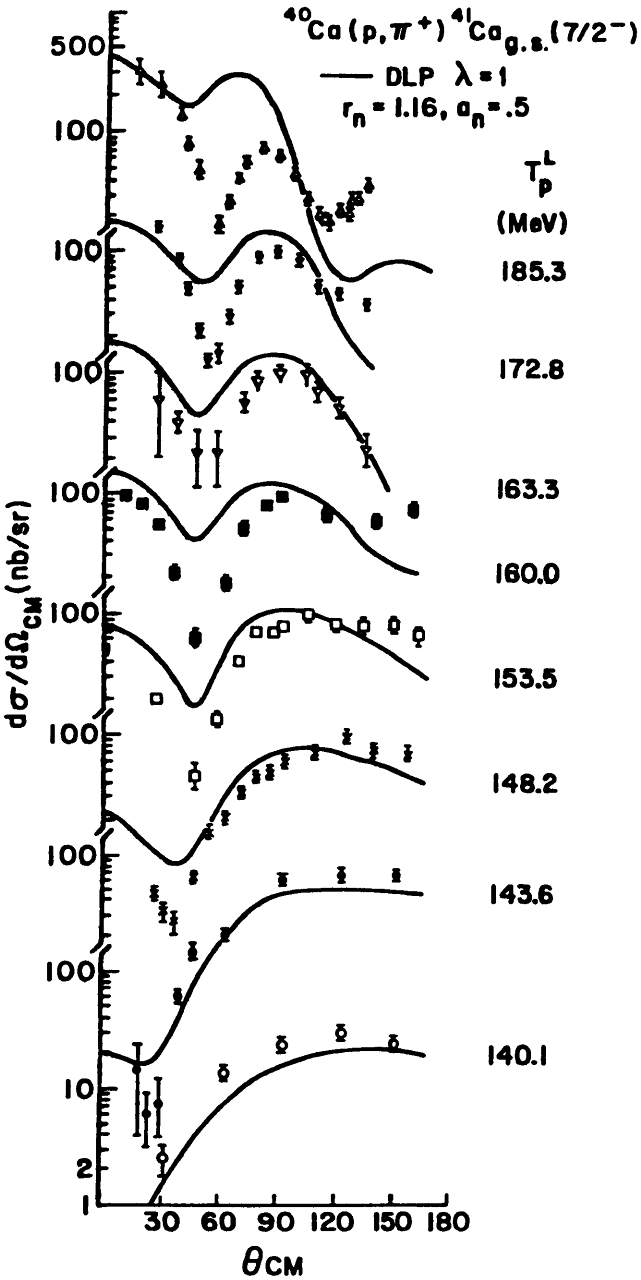

Figure 2. The energy dependence of the $^{40}Ca(p,\pi^+)^{41}Ca_{g.s}$ differential cross sections. The data for the highest three energies (185.3-163.3) are from UPPSALA, the rest from IUCF.

operator, the pion optical potential and the high momentum components of the bound neutron wavefunction, but also to competing reaction processes that are not included in the model. It should be instructive to extend the DWBA method to formally include the exchange diagrams arising from the target emission of pions.

1) M.C. Tsangarides, J.G. Wills, and R.D. Bent, Proc. of International Conference on Meson-Nuclear Physics, ed. E.V. Hungerford, Houston (1979), p. 192.

2) R.D. Bent, ibid, p. 142.

3) M.C. Tsangarides, Ph.D. Thesis, Indiana University (1979).

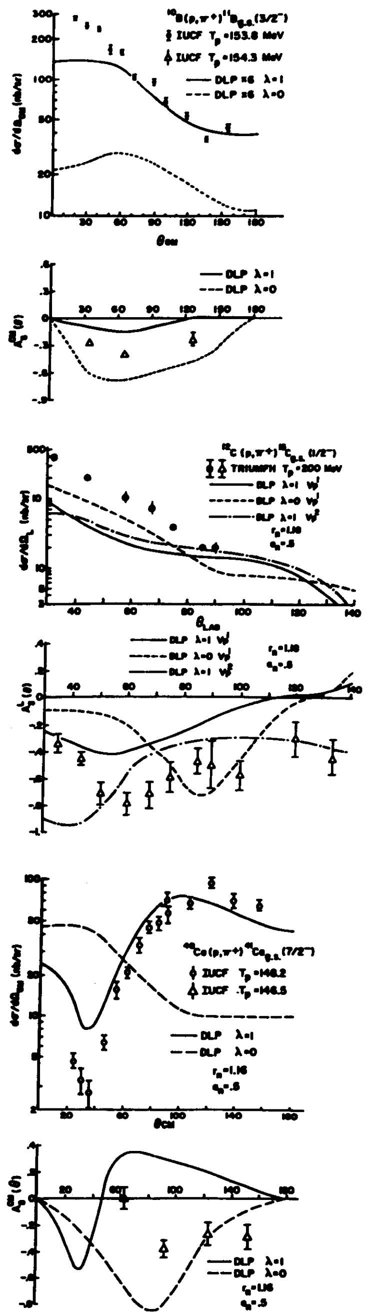

Figure 3. Data and DWBA calculations of the differential cross sections and asymmetries for the reactions $^{10}B(p,\pi^+)^{11}B_{g.s.}$, $^{12}C(p,\pi^+)^{13}C_{g.s.}$ and $^{40}Ca(p,\pi^+)^{41}Ca_{g.s.}$ The calculations were made with a local Laplacian pion-nucleus optical potential with off-shell damping (DLP), several different proton optical potentials (V_p^L) and either the static (λ=0) or Galilean invariant (λ=1) π-N interaction. r_n and a_n are the radius and diffuseness parameters of the Woods-Saxon well for the bound neutron.